

Photographs of Comets, and of the Milky Way. By E. E. Barnard.

I have, at various times, sent a number of photographs of the Milky Way, comets, &c., &c., to the Royal Astronomical Society, but these were not accompanied by any descriptions of the pictures.

It was my intention to describe in detail each one of these pictures to facilitate their study, and to put on record some of the more important features shown on the plates; for various reasons I was unable to do this when sending the pictures. I take the opportunity now, while sending a number of lantern slides from these and other pictures, to partially remedy the omission.

The Royal Astronomical Society has published some reproductions and lantern slides from the star and comet pictures previously sent. The present descriptions will also cover some of these, and for easy reference I shall indicate such pictures by the additional designation, *R.A.S.*, No. —, the number being that given in the “List of Reproductions of Celestial Photographs published by the Royal Astronomical Society” (see page 210). At best, these descriptions will cover only a few of the total lot of pictures sent by me to the R.A.S. at various times.

A few brief remarks of an historical nature may perhaps be important before entering on the descriptions.

While connected with the Lick Observatory, a series of photographs was made of all the different portions of the Milky Way which were visible from that latitude. This work was begun in the spring of 1889. The instrument employed, as is well known, was a 6-inch portrait lens of 31 inches focus, which bore the name of Willard, and the date 1859, and for this reason I have called it the “Willard lens” in all my work. This lens was used in the early days of wet plate photography for portrait work in a San Francisco photograph gallery. In the early times it was necessary to use a large aperture to lessen the duration of exposure in taking portraits; but after the invention of the quick dry plates, such a large lens became unnecessary, and this one was discarded for smaller and more convenient lenses.

Upon experimenting with this large lens, I found, on account of its wide field and great light-grasping power, that it was specially suited for the photography of the Milky Way, comets, &c. It was attached to a wooden camera box, and was first used by strapping it to the tube of the 6-inch equatorial. Latterly it was placed on an ordinary equatorial mounting, which did not permit continuous exposures to be carried across the meridian.

Besides the pictures of the Milky Way and nebulae, a number of photographs were secured of Swift's Comet of 1892, Holmes's

Comet of 1892, Brooks's Comet of 1893, and Gale's Comet of 1894.

The photographs of the Milky Way made with the Willard lens were the first to show its cloud forms and general structure. They opened up the means for a thorough study of the Milky Way such as had not before existed. Indeed, it is safe to say that little or nothing was known of the structural peculiarities of the Milky Way before these photographs were made. Visual means, on account of the smallness of the field of view, could give only the vaguest and most uncertain ideas of its wonderful structure. But the extended views given us by the wide field of the rapid portrait lens, place before us the Milky Way in all its sublimity. Every rift and chasm is shown ; the cloud forms, the great nebulous regions, and the singular alignments of stars, are all faithfully portrayed for permanent study. It is through the study of these details that we shall ultimately know something definite concerning the universe of stars in which our own Sun is placed.

For the study of the phenomena of the tails of comets, the portrait lens has shown itself most admirably suited. It has added an interest to the physical study of these bodies that did not exist previously ; for the most interesting of the phenomena shown by comets must always escape the visual observer and pass unknown, without the aid of the portrait lens and the photographic plate. Unlike the planets, the comets often traverse the entire solar system. They are, therefore, our only means of exploring the regions between the planetary orbits. Instead of ponderous bodies like the planets, they are but flimsy creations of enormous dimensions. They are thus likely to be easily subject to disturbances in their forms that would produce no perceptible effect on their motions. What these influences may be we do not know ; probably swarms or streams of meteors, which we know do exist in space, or possibly some other cosmical matter yet unknown. Such objects might be (and possibly have been) revealed to us by their effect upon the form of the comet's tail as it sweeps through space.

Swift's Comet of 1892.

This was the first comet to show to the photographic plate the extraordinary changes to which these bodies are subject. Indeed, if it had not been for the photographic plate we should have known nothing of the extraordinary changes that occurred in this comet and several that have since appeared.

Photographs taken April 4 and 5 showed that very rapid changes were taking place in the comet ; these changes seemed to culminate in the extraordinary phenomenon of April 7.

A study of the various photographs of this comet would seem to show that the observed phenomena can readily be explained by

disturbances in the nucleus, and by the ejection of the matter composing the head in a direction away from the Sun.

1892 April 6^d 15^h 30^m—16^h 35^m. (Lantern slide.)

In this photograph there is no resemblance to the appearance of the comet on preceding dates.

The tail consists of two broad streams, the northern of which is very bright, and the southern faint. The two streams merge together near the head, and at this point there is a quick bend in its southern side. A great deal of detail is shown in the brighter component in the form of bright streaks and patches. Fine threads or short "whisker tails" extend back from the head at considerable angles to the main tail. There are some indications present also of the remarkable disturbance which followed some twenty-four hours later.

1892 April 7^d 15^h 45^m—16^h 35^m. (Lantern slide.)
R.A.S., No. 10.

This picture shows a remarkable development in the tail at the back of the head, which might be taken for a secondary comet with a system of tails of its own. This singular development appears on one of a series of thin strands into which the tail has separated. This particular strand is the largest and brightest and somewhat curved, and becomes suddenly thinner near the head. These phenomena are very beautifully shown on the photograph. The large mass or secondary comet was doubtless thrown off from the nucleus or head some time during the preceding twenty-four hours, and must have had a very considerable velocity.

1892 April 24^d 13^h 50^m—16^h 10^m. (Lantern slide.)

This is a generally characteristic view of the comet. The tail partially separates into a number of streams, and on the north side is very sharply defined by what appears to be a thin black rift; if this edge of the tail is continued to the comet, it will pass south of the centre of the head, and consequently does not appear due to a force at that moment seated in the nucleus. The south portion of the inner bright tail is irregular near the head, and in this resembles some of the peculiarities of the tail of April 6.

1892 April 26^d 13^h 45^m—16^h 10^m. (Lantern slide.)

The multiple structure of the tail is well shown. It appears to be made up of a number of bright strands which centre in the head.

Holmes's Comet and the Andromeda Nebula.

1892 November 21^d 8^h 55^m—10^h 10^m. (Lantern slide.)

The apparent motion of the comet was so slow that it was possible to obtain a sharp picture of both comet and nebula—a circumstance that is not likely to happen again soon.

The short exposure (75^m) for this picture shows splendidly the rapid action of the portrait lens. Nearly everything that is usually shown in long exposure photographs of the nebula is brought out very clearly with this comparatively short exposure. There is a bright speck in the comet near its preceding edge; this, however, was a fixed star, and not the nucleus, as might be supposed.

An earlier picture, November 10, shows the comet round and sharply defined like a planetary nebula, with a symmetrical nebulous atmosphere surrounding it for some distance. That photograph also shows an irregular nebulous appendage about a degree to the south-east of the comet and attached to it by a hazy connection. This particular photograph (a copy of which is in the possession of the *R.A.S.*, No. 17) is very suggestive, taken in connection with the collision theory offered by several astronomers to account for the sudden appearance of this body. It was suggested that the object was not a comet in the ordinary sense of the word, but the result of a collision of two asteroids, for the orbit seemed to lie in the asteroid zone. The failure to see the comet previous to its sudden apparition near the Andromeda Nebula, its uncometary appearance, its peculiar freaks, and final utter disappearance from the heavens, connected with the nebulous appendage shown in the photograph of November 10, would strongly suggest that the object was not a comet at all, but more probably a result of some celestial accident. I think there is no question but this "comet" will never be seen again, and doubtless before now it has ceased to exist as an individual body.

I do not wish it to be understood that I endorse the theory that the apparition of this object was due to the collision of two asteroids. It may have been due to something besides the collision of one asteroid with another. We know too little about what may really exist in that region besides the individual asteroids themselves. Certainly many of the phenomena presented by this body were entirely uncometary. In some of the stages of its existence, however, its appearance was perfectly cometary. I have a photograph of it on December 10, when its diameter was about $\frac{1}{2}$ degree. It was a well developed comet then, with a nucleus and central brightness and a diffusion of the head away from the Sun. This is a beautiful picture, and the stars shine through the comet everywhere. A month later, after it had become excessively faint and diffused, it suddenly (1893 January 16) assumed the form of a bright nebulous star, and again underwent a process of expanding and diffusion, and finally disappeared.

1893 *Brooks's Comet.*

Photographically this was the most remarkable comet that has yet appeared. It is scarcely necessary to say that had it not been for the photographs obtained of it with the Willard lens, we should have known nothing whatever of the extraordinary phenomena which were presented by this body, and which I am convinced will some day be seen to have a bearing upon a problem outside of that of the comet itself and of the highest importance to astronomy.

I have selected five of the photographs of this comet for description, four of which bear directly upon the subject just mentioned.

1893 October 20^d 16^h 35^m—17^h 10^m. (Lantern slide.)
R.A.S., No. 14.

This picture shows the tail straight, but gradually widening, and diffused more or less to the north. From the northern side of the head a short diffused tail stretches out for half a degree or more, at an angle of some thirty degrees to the main tail. The apparent motion of the comet was in a direction nearly perpendicular to the length of the tail towards the north-east, and this is the direction from which the disturbance seemed to come in the later pictures.

1893 October 21^d 16^h 37^m—17^h 12^m. (Lantern slide.)
R.A.S., No. 9.

There is an utter transformation of the comet in this picture. The tail is larger and brighter and very much distorted, as if it had encountered some resistance in its sweep through space. This disturbance seems to have disrupted the north-east edge of the tail. The small side tail has apparently been swept away, while the more distant portion of the main tail is streaming in a very irregular manner. The entire picture is highly suggestive of an encounter with some sort of resistance. Is it possible the tail passed through a stream of meteors such as we know exist in space? Whatever the cause may have been, the appearance of the tail utterly excludes the idea of the phenomenon being due to irregular emission of the matter from the nucleus—an explanation quite satisfactory in the case of Swift's Comet.

In passing, this particular photograph seems to explain at least one of the ancient descriptions of a comet, viz., "a torch appeared in the heavens." The comet, as shown in the photograph, is sufficiently suggestive of a torch streaming irregularly in the wind.